

The Variable Radioisotope Heater Unit for the Cassini Spacecraft

Jacqueline C. Lyra and James W. Stultz
California Institute of Technology
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, California

ABSTRACT

The Cassini mission to Saturn has been undertaken by JPL for NASA and involves the European Space Agency (Titan Probe) and the Italian Space Agency (High Gain Antenna and Radar). The primary launch period for Cassini opens in October 1997. Following gravity-assists from Venus, Earth and Jupiter, necessary to allow the launch vehicle to inject a more massive spacecraft into the interplanetary trajectory, Cassini will arrive at Saturn in 2004. After delivering the Huygens probe to Saturn's moon Titan, Cassini will embark on its four year study of the Saturn system using its twelve science instruments. The 2,523 kg dry mass, power-limited spacecraft relies on three Radioisotope Thermoelectric Generators (RTGs) for electrical power. The spacecraft configuration is shown in Figure 1.

The Temperature Control Subsystem is faced with the requirement to design the spacecraft to an environment ranging from zero to almost three suns under limited spacecraft resources (i.e. electrical power and mass). To date the only other alternative to electrical power has been Radioisotope Heater Units (RHUs). A RHU provides one thermal watt by means of radioactive decay of its plutonium fuel. Traditional RHU application results in overtemperature concerns because it cannot be turned off like an electrical heater.

A new concept called a Variable Radioisotope Heater Unit (VRHU) was developed at JPL (Figure 2). It combines the heating and temperature control functions into one non-electrical self-controlled unit. Each VRHU consists of a cylindrical RHU holder that holds up to three RHUs and rotates on bearings when driven by a temperature sensitive bimetallic spring. The high emittance half of the cylindrical RHU holder is painted with a low α_s/ϵ paint while the other half is covered with a 20-layer insulation blanket. Due to the possibility of exposure to almost three suns, the outer layer of the blanket is made of low α_s/ϵ second surface aluminized Kapton. The interior layers are made of embossed aluminized Kapton.

The mechanism works such that when the hardware temperature is below the set point temperature for the bimetallic springs the holder rotates so the high emittance surface faces the interior of the hardware (heat in) and the blanketed side faces space (full closed position), see Figure 3. Using the same principle, when the hardware is above the set point temperature the RHU holder rotates to expose the high emittance side to space (heat out) while the blanketed side faces the interior of the hardware (full opened position). The bimetallic spring can be calibrated for a desired open point. The full open position will occur 28°C above the full closed set point. Figure 2 shows a VRHU in a half open position.

The Cassini spacecraft currently baselines up to five VRHU units on each of the four thruster clusters (Figure 4) for a total of twenty units. The thruster cluster thermal design relies on approximately (at least) two watts of heat source from each VRHU in a full closed position.

This paper presents the development of the VRHU from concept to the flight design with emphasis on the results from the thermal development and flight characterization tests. The resulting flight cluster predicted temperatures with the VRHU heater configuration is shown against the temperature requirements.

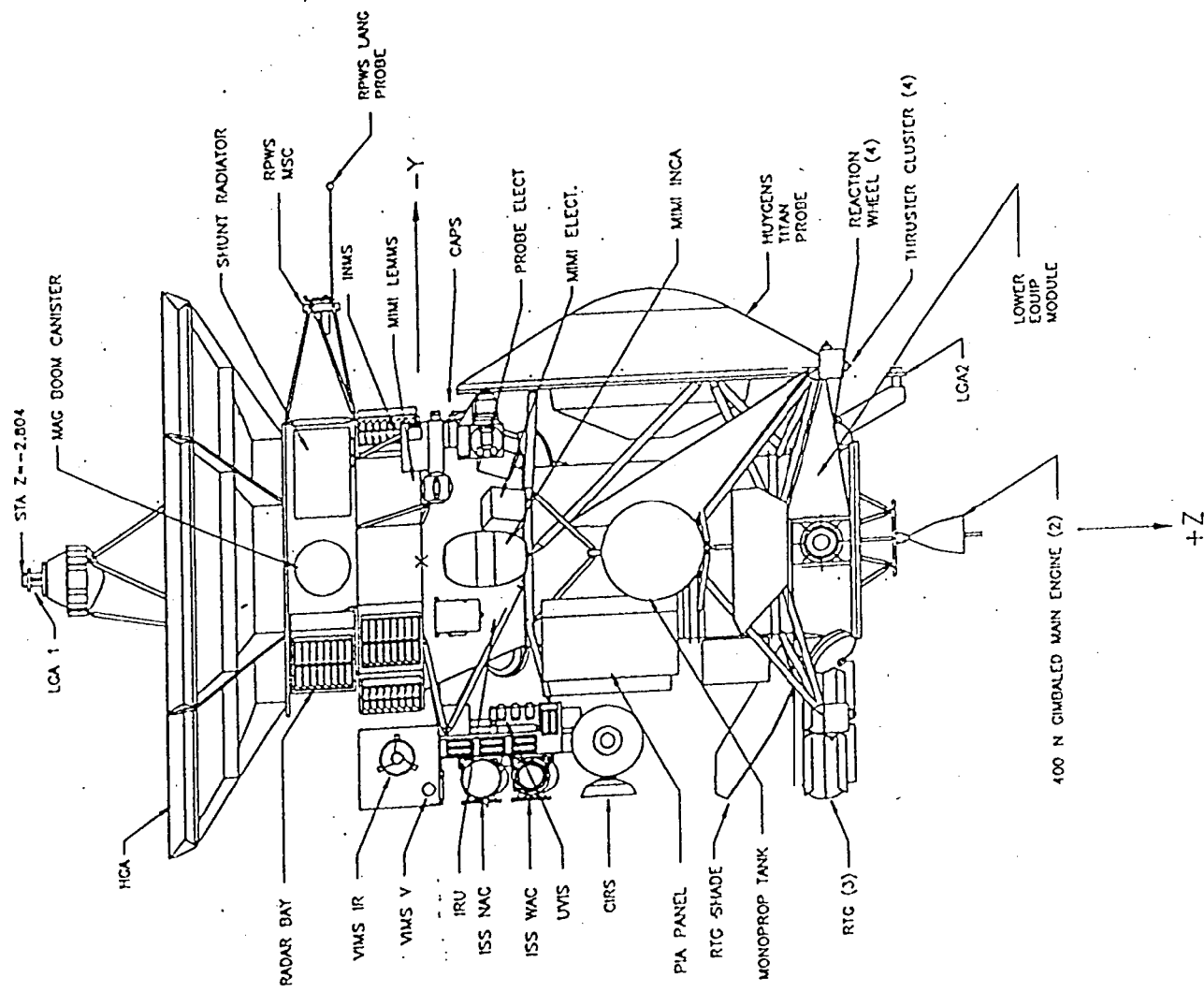


FIGURE 1. Cassini Spacecraft

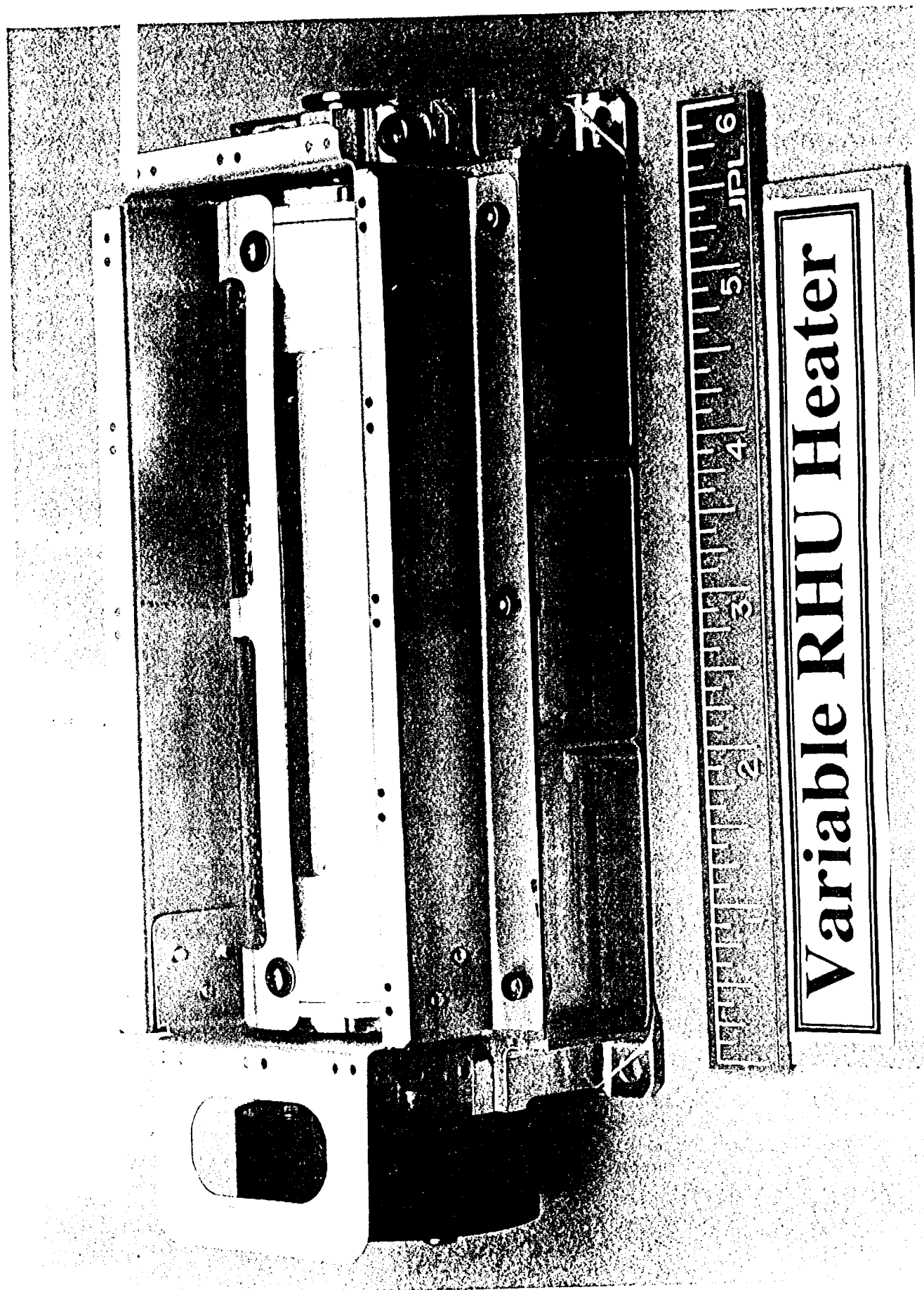
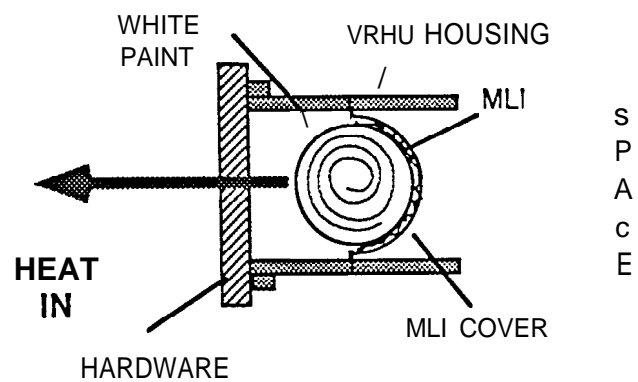
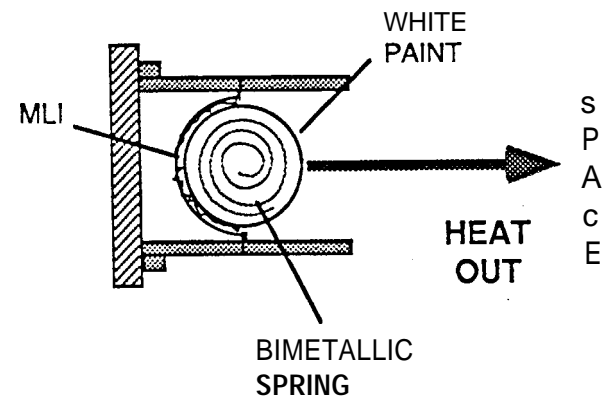


FIGURE 2. The Variable RHU Heater



HARDWARE TEMPERATURE
BELOW VRHU SET POINT
(FULLY CLOSED)



HARDWARE TEMPERATURE
ABOVE VRHU SET POINT
(FULLY OPEN)

FIGURE 3. Variable Radioisotope Heater Unit Concept

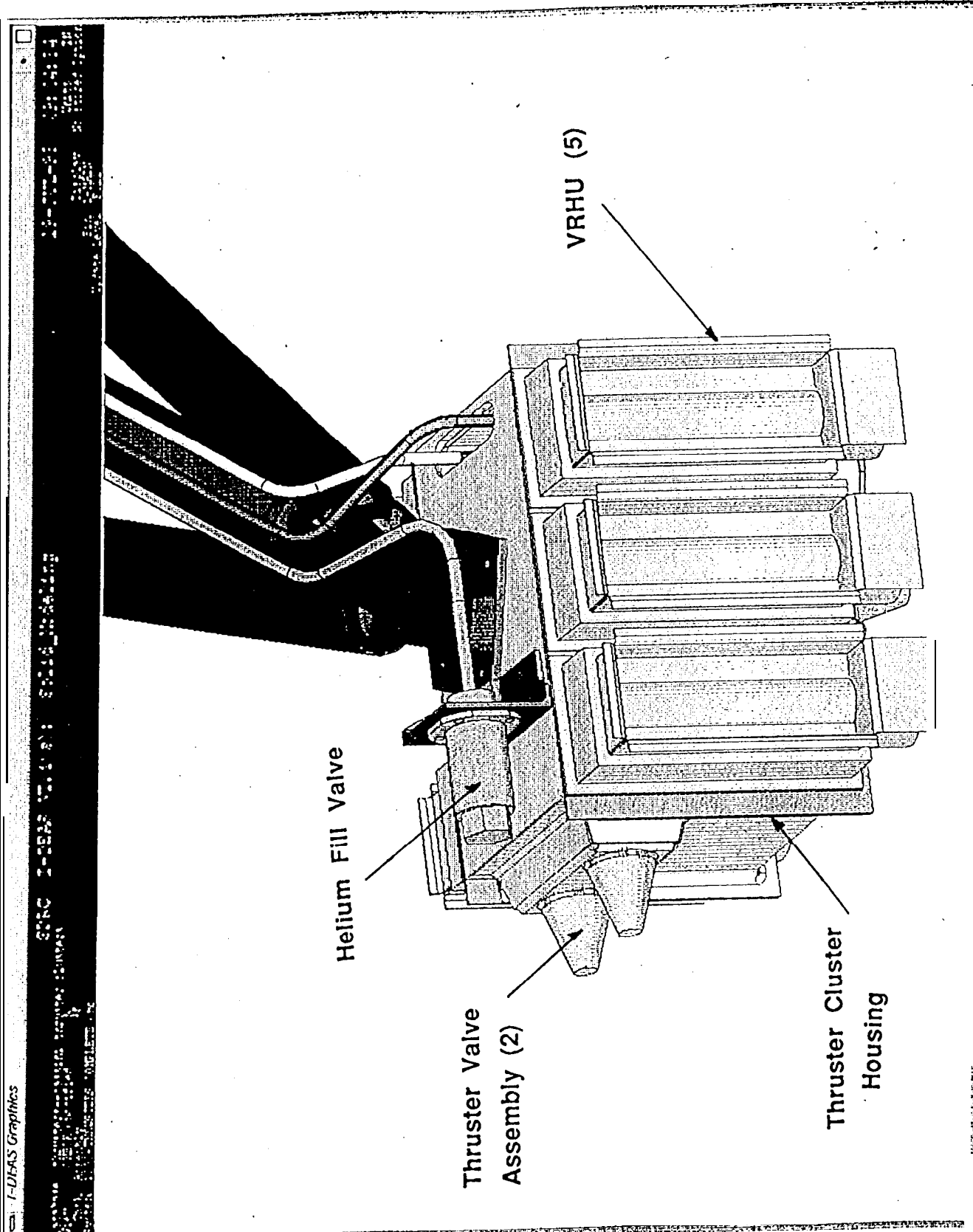


FIGURE 4. Cassini Thruster Cluster and VRHUs